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ABSTRACT

Traditionally, earth and space sciences have been taught in American schools from a Eurocentric and/or androcentric viewpoint. In the past, emphasis in earth and space science curricula in schools has been placed on "the scientific method" and on "famous men in science." This view of the history of earth and space sciences excludes the contributions of many culturally diverse individuals and groups from history (Pearson & Bechtel, 1989) and deprives children of vitally needed role models. One goal of science education, including earth and space science education, as expressed in "The Liberal Art of Science," is "to increase the numbers of women, Blacks, and Hispanics who major in natural sciences and pursue science and science-related careers" (American Association for the Advancement of Science, 1990). Actualization of this goal will require that culturally diverse children be involved in learning and doing science. This paper seeks to examine the historical roots of earth and space sciences as they are presented in currently used earth and space science textbooks in American public schools and to propose a culturally transforming model for those curriculum materials. (Author)

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A Social Reconstructionist View of the History of Earth and Space Sciences

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Abstract

Traditionally, earth and space sciences have been taught in American schools from a Eurocentric and/or androcentric viewpoint. In the past, emphasis in earth and space science curricula in schools has been placed on "the scientific method" and on "famous men of science". This view of the history of earth and space sciences excludes the contributions of many culturally diverse individuals and groups from history (Pearson & Bechtel, 1989) and deprives children of vitally needed role models. One goal of science education, including earth and space science education, as expressed in The Liberal Art of Science, is "to increase the numbers of women, Blacks, and Hispanics who major in natural sciences and pursue science and science-related careers" (AAAS, 1990, p. 64). Actualization of this goal will require that culturally diverse children be involved in learning and doing science. This paper seeks to examine the historical roots of earth and space sciences as they are presented in currently used earth and space science textbooks in American public schools and to propose a culturally transforming model for those curriculum materials.

A Social Reconstructionist View of the History of Earth and Space Sciences

The American Association for the Advancement of Science has stated that one goal for science education in this nation is "to increase the numbers of women, Blacks, and Hispanics who major in natural sciences and pursue science and science-related careers" (AAAS, 1990, p. 64). In order to achieve this goal, white females and children of color need to perceive science, including earth and space sciences, as a domain where they may experience success. It has been widely reported that science instruction in this nation is textbook driven, that teachers rely heavily on textbooks as the primary source of information when teaching children. It is therefore appropriate to examine the image(s) of science and scientists portrayed in textbooks and related curricular materials from the perspective of culturally diverse children and white females. What image(s) of science and scientists are portrayed to culturally diverse children and white females?

Problem

United States history books traditionally begin with a chapter on the "Age of Exploration". Children in our nation's schools read of the discovery of America by Christopher Columbus, Leif Erikson, Vasco Nunez de Balboa and other European "explorers". From a Native-American perspective, the United States of America couldn't have been found, because it was never lost. In this nation, we tend to view our nation's history from a European perspective, from a Eurocentric viewpoint. We present history to children as if civilization began in the United States when European explorers and settlers arrived on these shores, as a result of this perspective the contributions of indigenous peoples to the history of our nation are lost. Viewing the world from a Eurocentric perspective is not limited to social studies education but also manifests itself in science education. Earth and space science textbooks present a strong Eurocentric view of scientific discovery and methods to children. Additionally, earth and space science textbooks tend to present scientific discovery from an androcentric viewpoint, that is, from a man-centered rather than a human-centered orientation. The contributions of culturally diverse individuals and Anglo women are excluded from classrooms when an androcentric/Eurocentric viewpoint is used (Taton, 1963; Alic, 1986; Herzenberg, 1986; Kahle; 1985; & Pearson & Bechtel, 1989).

Although the omissions of the contributions of culturally diverse individuals and women from science curricular materials may not be intentional, the hidden message conveyed to children is that these individuals were not and are not important scientists (Council on Interracial Books for Children, 1979). This message victimizes all of us. Men and women of

color and white females lack successful earth and space science role models and white males develop a feeling of unfounded superiority (Van Sertima, 1986). A classical study of textbooks (Sadker & Sadker, 1979) undertaken nearly two decades ago revealed that the most widely used elementary texts in science, math, reading, spelling, and social studies contained females and culturally diverse individuals in fewer than one third of the illustrations. While many publishing companies have made a concerted effort to improve the portrayal of culturally diverse individuals and white females in their current publications, the reality is that proportional portrayal of women and minorities has yet to be achieved in instructional materials (Curriculum Framework and Textbook Development Unit, 1986). A more recent study (Barba, in press) of five commonly used textbooks indicates that women and culturally diverse individuals continue to be presented in relatively low numbers (see Figure 1).

Figure 1.
Distribution of "Famous Scientists" by Gender
and Ethnicity in Widely Used Science Textbooks

Ethnicity	Males	Females	Total
Hispanic/Latino	4 (1.76%)	3 (1.32%)	7 (3.08%)
SE Asian	8 (3.52%)	4 (1.76%)	12 (5.28%)
African/Afro-Am	13 (5.73%)	7 (3.08%)	20 (8.81%)
Anglo/European	153 (67.40%)	32 (14.10%)	185 (81.50%)
Native American	2 (0.88%)	1 (0.44%)	3 (1.32%)
Total	180 (79.30%)	47 (20.70%)	227

Before children can actualize their interest in science, they must be made aware of the opportunities for their participation in scientific endeavors (California State Board of Education, 1989).

Eurocentric Traditions

The European tradition in the history of science is embodied in the "scientific method" and in the contributions of European scientists (and those of European heritage) to that body of knowledge (Al-Daffa & Stroyls, 1984). The questions that geologists, paleontologists, oceanographers and astronomers ask, the way(s) that they explore the world around them, their sources of data, and the ways that they view truth and knowledge are derived from this European tradition. Writers of earth and space science textbooks used by children are trained in the Eurocentric scientific tradition and thus their writings, the earth and space science textbooks provided to American children, reflect their training. The "scientific method" is described in many science textbooks (Bierer, Lien, & Silberstein, 1987; American Chemical Society, 1988; Merrill Publishing; Slesnick, Balzer, McCormack, Newton, & Rasmussen, 1985; & Oram, 1986) as a five step method for investigating the natural world and includes: (a) stating the problem, (b) collecting information, (c) forming a hypothesis, (d) testing the hypothesis, and (e) drawing a conclusion. Within this tradition, Brahe discovered the nova, Bradley measured the speed of light, Amundsen discovered the South Pole, and Rossi detected a cosmic X-ray source in Scorpio (Miller, Miller, Millar & Millar, 1989).

Frequently, earth and space sciences are presented to children as a single way of investigating the world rather than as the multifaceted constructs they really are. If a scientist or a group of people do not follow the "scientific method formula", is the "discovery" science? Probably not, at least in our earth and space science textbooks. There is a snobbery within the scientific community about the type of scientific discoveries which are considered to be of worthy of note (Kass-Simon & Farnes, 1990; & Harding, 1991). Many scientists and historians of science give weight only to scientific discoveries which use the European language

and standards of science as legitimate indicators of merit and deny the merit of discoveries which are derived from other investigative methods (Harding, 1991). Eurocentric science is not only dominated by the "scientific method", it is also dominated by discoveries attributed to white males.

Androcentric Traditions

The androcentric model of the history of science gives credit for scientific "discoveries" to particular individuals, normally white males. Within this tradition, Halley and Humason are credited with discovering comets (McGraw-Hill, 1966). Andreija Mohorovicic is credited with discovering the boundary surface between the mantle and the crust (McGraw-Hill, 1966). Galileo Galilei is recognized as one of the first astronomers to use a telescope (Howard, 1951). Charles Lyell is remembered for his work in identifying periods of geologic time (Debus, 1968). The Theory of Continental Drift and the naming of the protocontinent Pangaea are credited to Alfred Wegener (Asimov, 1964).

When we refer to the stars Aldebaran, Betelgeuse, Algol and Altair, we say that they were named by "Arab astronomers" without reference to which specific astronomer named the stars. The practice of mentioning discoveries in earth and space sciences without referencing the particular astronomer, geologist, or oceanographer who made the discovery diminishes the value of that scientist and deprives children of vitally needed role models. To speak of paleomagnetism and not to mention the name of Seiya Uyeda (McGraw-Hill, 1980) is to deprive children of a "significant other" in their lives.

Contributions made to earth and space sciences by women, by culturally diverse individuals, and by groups of individuals are rarely included in textbooks. By insisting on identifying a particular individual as being a "discoverer" of knowledge, we neglect the fact that many cultures do not value individualism and "discovery", but rather see the group good as being the important entity. The discoveries of the rings of Saturn, the moons of Jupiter, and the spiral structure of the Milky Way galaxy made by the Dogon tribe in West Africa in about 1250 A.D. are not viewed as discoveries by most historians of science (Van Sertima, 1986) because they are group rather than individual achievements.

Ways of Viewing the History of Science

Ogbu (1992) and Sleeter and Grant (1987) report that five models for addressing equity issues are currently used in this country: (a) assimilationism, (b) a human relations approach, (c) single-group studies, (d) multiculturalism, and (e) social reconstructionism. These viewpoints are manifested in the way(s) that we present the history of science and/or discovery to children. Adherents of assimilationist viewpoints believe that the gender and ethnicity of scientists portrayed in textbooks and other curricular materials is unimportant. Authors writing from this worldview commonly use stories of the lives of white males as illustrations of "successful" scientists. Proponents of an assimilationist tradition believe that white females and culturally diverse individuals can be successful in science-related careers if they emulate previous "well known" scientists who may or may not be from the child's gender, ethnic, and/or racial group. Textbooks and other curricular materials written from this worldview typically mention only male scientists of European descent as being "famous" scientists. Assimilationist models for viewing the history of science and discovery address neither the Eurocentric, nor the androcentric nature of the history of science as it is presented to children.

Authors writing earth and space science textbooks and curricular materials who ascribe to a human relations approach to equity issues will typically include some exemplary or model white female and/or culturally diverse scientists in their works. The purpose of a human

relations approach is to improve interpersonal relations (Ogbu, 1992, p. 6). Those who write from this perspective will frequently include "representative" culturally diverse individuals and females in their materials, in boxes appended to the sides of pages or the ends of chapters. This is referred to an "additive model" (Gilbert & Gay, 1985). The additive model of history holds that providing underrepresented minority students with successful culturally diverse scientists as role models addresses the needs of students to have significant others in their lives (California State Board of Education, 1989). Current authors of earth and space science textbooks will sometimes include photographs of astronauts such as Franklin Chang-Diaz, Guion Bluford, Ellison Onizuka and Sally Ride in their textbooks. Sometimes textbooks will include biographical "blurps" or footnotes on culturally diverse scientists such as Subrahmanyan Chandrasekhar, Chang Heng, Don Fausto D'Elhuyar, Andres Manuel Del Rio, I-Hsing, or Michiko Ishimure at the sides of pages or at the end of chapters. While a human relations approach to the history of science addresses the Eurocentric and androcentric nature of the history of science as it is presented to children, this approach is viewed by some as being "tokenism".

A single-group studies approach to the history of science is based on a concentrated study of groups within our society. Projects such as Black history month or a series of posters of famous women scientists typify curricular materials produced within this worldview. Like the human relations approach, a single-group approach uses an additive model. The distinction being that a single-group approach, focuses on a large number of individuals in a particular ethnic or cultural group rather than one individual from each group. Within this context, one could mention that an ancient Chinese scholars, such as Shen Kua had invented the compass in about 1070 A.D. (Daintith, Mitchell & Tootill, 1981). One could mention that a rich body of information about earth sciences has come from Africa and that Albategnius who measured the angle between the Earth's orbital and the equatorial planes (Asimov, 1964) is typical of these scientists. If one were studying female scientists, one could mention that Florence Bascom mapped the Mid-Atlantic Piedmont area. This additive model appends culturally diverse role models and women to the list of white male European scientists already mentioned in textbooks, thus perpetuating the notion that these scientists may not be worthy of note in the main body of the textbook. The single-group studies model for the history of science addresses the Eurocentric and androcentric nature the history of discovery, but it does not address the fact that not all groups value individual discovery, nor does it address cultures which value oral traditions.

A list of culturally diverse and Anglo/European women in earth and space sciences, who fulfill the Eurocentric model for "scientific discovery" is shown in Figure 2 below:

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A multicultural prospective seeks to include the contributions of females and culturally diverse individuals whenever possible through curricular materials. According to Rubalcava (1991), a multicultural approach fosters pride in minority cultures, helps minority students develop new insights into their culture, reduces prejudice and stereotyping, and promotes intercultural understandings. In this model, the contributions of culturally diverse men and women are woven throughout the main fabric of the textual materials. Specific mention is made of those individuals who have made contributions to science. A multicultural approach seeks to integrate culturally diverse role models throughout the main body of the textbook, rather than using an additive model. While this model addresses the Eurocentric and androcentric nature of the history of science and discovery as it is presented to children, it does not address the fact that not all societies value individual initiative. Neither does a multicultural approach address oral traditions, nor the historical bias in reporting on the "discoveries" of women and culturally diverse individuals.

Oral Traditions and Group Discoveries

The oral tradition has often not been recognized as a valid method for transmitting information in the scientific community. The basic axiological and epistemological assumptions of science hold that oral traditions are not valid sources of information. Thus, some individuals in the scientific community have labeled traditional scientific practices from culturally diverse groups as folk practice and/or quackery. Some scientists and historians of science discount oral contributions to earth and space sciences as "old wive's tales" because these discoveries were made without the controls and written documentation that accompanies scientific "discoveries". Certainly, there are oral traditions and histories which are scientifically unfounded and unjustified in the scientific realm, but this should not discount all oral traditions as being "bad science" and unworthy of mention to our children.

Nearly 2,000 years ago, Africans living in what is present day Tanzania discovered a technology for producing carbon steel, a method which was not matched in Europe until the mid-nineteenth century (Van Sertima, 1986). This discovery is deemed by many historians of science to be early military technology or "tribal practice", not science. The discovery of mining procedures used to extract silver ore from Potosi mountain developed by the Quencha Indians is a group discovery which was passed orally from father to son (Weatherford, 1988). Neither the Tanzanians nor the Quenchas used the "scientific method" to derive new knowledge, nor did they take individual credit for their discoveries or report their findings before scientific societies, rather they passed knowledge orally from one generation to another. The oral tradition as a means of reporting group discoveries from one generation to another needs to be addressed by historians of science (Ronan, 1982) and to be included in earth and space science textbooks for children.

Bias in Reporting

The most insidious barrier to the inclusion of culturally diverse individuals and women scientists in mainstream science is much more complicated because it focuses upon the historically oppressive nature of our society. There was a time in our history when the contributions and life works of women and culturally diverse individuals were not deemed to be as important as the "discoveries" of Anglo men. During this time period, a wife's "discoveries" were seen as being her husband's property, just as a slave's inventions were seen as being the property of his owner. Caroline Herschel published many of her findings under the name of her brother William. Johann Hevel's work in astronomy was actually a collaborative effort reflecting his work and that of his wife. Annie Jump Cannon worked quietly on her stellar classification system at Harvard. Her work and that of her female colleagues resulted in the publication of the Henry Draper Catalogue (which contains the analysis of the spectra of 225,300 stars) which became the basis of H-R diagram. Cannon, Maury, and Mayall received relatively little recognition for their work, while their male colleague, Edward Pickering received acclaim from his colleagues in the scientific community.

Many women and culturally diverse researchers have also been plagued by a lack of financial resources, lack of collegiality, and a lack of opportunity to participate in mainstream science activities. For example, George Washington Carver taught only in Black colleges and his laboratory was furnished with discards collected from the city dump, while the laboratories of his white peers were equipped by endowments from their universities (Van Sertima, 1986). Carver was forced to work within an industrial arts setting, rather than within a mainstream science laboratory. The lack of a properly equipped working environment crippled Carver's ability to conduct the in-depth studies he would have wished. Culturally diverse scientists and Anglo/European women have frequently been isolated from the rest of the scientific community. Black research scientists like Charles Turner, Percy Julian, and Ernest Just were excluded from full participation in the scientific community (Van Sertima, 1986), as were white

females like Annie Jump Cannon, Florence Bascom, Williamina Fleming, Ida Ogilvie, Julia Gardner, Eleanora Bliss Knopf, Anna Jonas Stose, and Doris Reynolds (Yost, 1943). Culturally diverse scientists and Anglo/European women were denied the professional interactions, laboratories, opportunities for promotion and tenure, and access to public libraries accorded their white male counterparts. Worst of all, these scientists were denied the opportunity in many cases to mentor the next generation of scientists.

Culturally Transforming Viewpoint - Social Reconstructionism

While the addition of information about the contributions of women and culturally diverse individuals may improve the quality of instruction for children, this action alone does not address the Eurocentric nature of science. Only when the contributions of women and culturally diverse individuals are woven into the fabric of textual passages and when group discoveries and oral traditions are valued, do the basic axiological and epistemological foundations of science change. If science instruction is to become inclusive rather than exclusive, then change is needed in the way that we view knowledge and children's ownership of that knowledge.

Suzuki (1984) suggests that we use a culturally transforming model for history of discovery. In earth and space sciences, a culturally transforming model would require the addition of culturally diverse individuals and groups to our current curricular materials and a review of the traditional values upon which the discipline is based. Firstly, earth and space science textbooks need to include the oral tradition of recording information into the history of science that we present to children. Secondly, earth and space science textbook authors should recognize that all scientific discovery does not always center on individuals. Some cultures value group discovery and not individual initiative; thus group discoveries need to be included in our instructional materials. Thirdly, earth and space science textbooks should include a broadened definition of the scientific method to include valid "discoveries" which research has shown to be effective and which may not have been derived through traditional Eurocentric methods. Finally, bias in reporting the discoveries of culturally diverse individuals and women (e.g. attributing "discoveries" to the wrong author or ignoring the contributions of certain individuals or groups) in earth and space sciences needs to be eliminated from our curriculum materials. The inclusion of the contributions of all men and women who have contributed knowledge to our current day understanding of earth and space sciences enriches us all.

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Name		Years	Contribution to Earth and Space Sciences
Albategnius		(858-929 AD)	Measured angle between Earth's orbital and equatorial planes
Arzachel		(circa 1080 AD)	Planets move in elliptical orbits
Bascom	Florence	(1862-1945)	Mapped the Mid-Atlantic region of the Appalachian Piedmont
Brahmagupta		(598-665 AD)	Planets of Mars and Venus moved in oval orbits
Cannon	Annie Jump	(1863-1941 AD)	Classification of stars by spectral analysis
Cano	Juan Sebastian del	(1460-1526 AD)	First man to circumnavigate the globe
Chandrasekhar	Subrahmanya	(1910 -)	Life cycle of a star from birth to death
Chang Heng		(78-142 AD)	First working seismograph
D'Elhuyar	Don Fausto	(1755-1833 AD)	Discovered the element tungsten in wolframite
Del Rio	Andres Manuel	(1764-1849 AD)	Discovered the element vanadium in the mineral patronite
Fleming	Williamina	(1857-1911 AD)	Discovered 10 novae, 300 variable stars and 51 gaseous nebulae
Herschel	Caroline	(1750-1848 AD)	Discovered 8 comets
I-Hsing		(681-727 AD)	First to measure astronomically the length of a meridional line
Ishimure	Michiko	(1927 -)	Heavy metal (mercury) poisoning
Kovalevskaya	Sofya	(1850-1891 AD)	Composition of the rings of Saturn
Kuno	Hisashi	(1910-1969 AD)	Studies of crystal formation from magma
Matuyama	Motonori	(1884-1958 AD)	Magnetic reversals in geologic past
Maury	Antonia Caetana	(1866-1952 AD)	First to discover a double star
Meitner	Lise	(1878-1968 AD)	Discovered thorium C and protactinium & fission
Mela	Pomponius	(circa 44 AD)	First to define earth's climatic zones
Raman	Chandrasekhara	(1888-1970 AD)	Raman spectra - infra-red range of spectrum
Reynolds	Doris	(1899 -)	Sequence of mineral replacement in granitization process
Saha	Meghnad	(1894-1956 AD)	Thermal ionization of elements
Shen Kua		(1031-1095 AD)	Discovery of the magnetic compass
Su Sung		(1020-1101 AD)	Invention of the celestial glove or armillary sphere
Uyeda	Seiya	(1929 -)	Discovery of paleomagnetism
Wu	Chien-Shiung	(1912 -)	Beta disintegration in radioactive decay